DEFENCE DÉFENSE

Ejection clearance in the CF-188 aircraft

P. Meunier

Defence R&D Canada

Technical Memorandum
DCIEM TM 2001-136
August 2001

National Defence Défense nationale

Canada

Ejection clearance in the CF188 aircraft

P. Meunier

Defence and Civil Institute of Environmental Medicine

Technical Memorandum

DCIEM TM 2001-136

August 2001

Author

Pierre Meunier

Approved by

L. Magee

Simulation and Modelling for Acquisition, Rehearsal, and Training

Approved for release by

K.M. Sutton

Chair, Document Review and Library Committee

Abstract

An ejection clearance trial was performed on the CF188 to determine the longest buttock-knee length that can eject without hitting the aircraft structure. Nine large subjects (pilots) ranging from 63rd to 99.9-percentile buttock-knee length were recruited for the study. The tests were carried out both in summer and winter flying clothing using the current Simplified Combined Harness (SCH) and the US Air Force Torso Harness (TH), which required a modified seat.

Although the study was not designed to assess shin clearance, the preliminary indication is that shin clearance to the main instrument panel is rather limited. Some of the individuals tested had little or no clearance in winter clothing.

The glareshield was found to be the limiting factor upon ejection, followed by the DDI. However, since the glareshield is quite flimsy it does not appear likely to cause knee injury during ejection. Nevertheless, with the current harness (SCH), buttock-knee lengths up to the CF aircrew selection limit of 673 mm (99th percentile) will clear the glareshield. This limit may be increased somewhat (~12 mm) if the glareshield is deemed to be non-hazardous.

As evaluated, the torso harness and modified seat are more limiting than the current SCH by nearly 20 mm. However, thinner seat cushions and back pad would probably bring the buttock-knee length limit of the torso harness in line with that of the SCH.

Résumé

Des tests d'éjection ont été faits dans le but de déterminer la limite supérieure de la longueur fessier-genou permettant une éjection sans risque. Neuf grands sujets (pilotes) couvrant du 63ième au 99.9ième centile de longueur fessier-genou ont été recrutés pour l'étude. Les essais ont été effectués en habillement de vol d'été et d'hiver, avec le harnais combiné simplifié (HCS) et le harnais de torse (HT) de la marine américaine, ce dernier nécessitant un siège modifié.

Bien que l'étude n'ait pas été conçue pour évaluer le dégagement du tibia, les résultats préliminaires montrent que l'espace entre le tibia et le tableau de bord principal est plutôt restreint. Certains des individus examinés avaient peu ou pas d'espace en habillement d'hiver.

Le protecteur d'éblouissement s'est avéré le facteur limitant, suivi du DDI. Cependant, puisque le protecteur d'éblouissement est mince et peu solide, il ne semble pas apte à blesser les genoux durant l'éjection. Néanmoins, avec le harnais actuel (HCS), les pilotes ayant une longueur fessier-genou jusqu'à la limite actuelle de sélection des pilotes des forces canadiennes, c'est-à-dire 673 millimètres (99ieme centile), éviteront le protecteur d'éblouissement. Cette limite peut être augmentée quelque peu (~12 millimètres) si le protecteur d'éblouissement est considéré comme étant sans danger.

Tel qu'évalué, le harnais de torse ainsi que son siège sont plus limitant que le HCS actuel par près de 20 millimètres. Cependant, des coussins et garnitures plus minces ramèneraient probablement la limite de longueur fessier-genou du harnais de torse en ligne avec celle du HCS.

This page intentionally left blank.

Executive summary

Mass has traditionally been used as the sole anthropometric determinant for CF188 aircrew (Lefebvre, 2000). Currently, the CF188 ejection limits are such that they accommodate an all-inclusive throw mass of 183 kg (403 lbs) to 220 kg (484 lbs). This translates to a nude body mass range of 62 kg (136 lbs) to 98/102 kg (215/225 lbs), depending on the clothing and survival kit configuration. These limits exclude an estimated 6-8% of male aircrew and approximately 20% of females.

The CF-18 Escape Systems Modernization Project was initiated to expand the range of allowable nude body mass to include individuals between 53 kg (116 lbs) to 111 kg (245 lbs). This would virtually eliminate mass restrictions for both males and females. However, since the anthropometric accommodation envelope of the cockpit has not yet been established in the CF188, it is not known whether all small or large occupants would be able to safely eject.

The first phase of the accommodation assessment involved an ejection clearance trial. The objective was to determine the upper limit of buttock-knee length that can eject without hitting the aircraft structure. Nine large subjects (pilots) ranging from 619 mm to 694 mm (63^{rd} to 99.9^{th} percentile) in buttock-knee length were recruited for the study. The tests were carried out both in summer and winter flying clothing, using the current Simplified Combined Harness (SCH) and the US Air Force Torso Harness (TH), which used a modified seat.

Although the study was not designed to assess shin clearance, the preliminary indication is that shin clearance to the main instrument panel is rather limited. Some of the individuals tested had little or no clearance in winter clothing. More details will be available following the second phase, where a complete cockpit accommodation assessment will be made.

The glareshield was found to be the limiting obstacle, followed by the DDI. However, since the glareshield is quite flimsy, it does not appear likely to cause knee injury during ejection. Nevertheless, with the current harness (SCH), buttock-knee lengths up to the CF aircrew selection limit of 673 mm (99^{th} percentile) will clear the glareshield. This limit may be increased somewhat (~12 mm) if the glareshield is deemed to be non-hazardous.

As evaluated, the torso harness and modified seat are more limiting than the current SCH by nearly 20 mm. Thinner seat cushions and back pad would probably bring the buttock-knee length limit of the torso harness in line with that of the SCH.

Meunier, P. 2001. Ejection clearance in the CF188 aircraft. DCIEM TM 2001-136. Defence and Civil Institute of Environmental Medicine.

Sommaire

Le poids a été traditionnellement utilisé comme cause déterminante anthropométrique unique pour l'équipage aérien CF188 (Lefebvre (2000)). Présentement, les limites du CF188 sont telles qu'elles permettent l'éjection d 'une masse totale allant de 183 kg (403 livres) à 220 kg (484 livres). Ceci représente un intervalle de masse corporelle de 62 kg (136 livres) à 98/102 kg (215/225 livres), selon la configuration d'habillement. Ces limites excluent environ 6-8% des pilotes mâle et approximativement de 20% des pilotes femelles.

Le projet de modernisation de systèmes d'évasion du CF-18 a été lancé pour augmenter l'intervalle de masse corporelle pour inclure des individus entre 53 kg (116 livres) à 111 kg (245 livres). Ceci éliminerait presque entièrement les restrictions de masse pour hommes et femmes. Cependant, puisque l'enveloppe d'accommodation anthropométrique de l'habitacle n'a pas encore été établie dans le CF188, il n'est pas possible de savoir si de plus petits ou de plus grands occupants sont en mesure de piloter cet avion.

La première phase de l'évaluation a consisté à mesurer le dégagement d'obstacles durant l'éjection. L'objectif était de déterminer la limite supérieure de la longueur fessier-genou permettant une éjection sans risque de frapper la structure d'avion. Neuf grands sujets (pilotes) couvrant du 63ieme au 99.9 centile de la longueur fessier-genou ont été recrutés pour l'étude. Les essais ont été effectués en habillement de vol d'été et d'hiver, avec le harnais combiné simplifié (HCS) et le harnais de torse (HT) de la marine américaine, ce dernier nécessitant un siège modifié.

Bien que l'étude n'ait pas été conçue pour évaluer le dégagement du tibia, les résultats préliminaires montrent que l'espace entre le tibia et le tableau de bord principal est plutôt limité. Certains des individus examinés ont eu peu ou pas de dégagement en habillement d'hiver. Plus de détails seront disponibles après la deuxième phase, où une évaluation complète d'accommodation de l'habitacle sera faite.

Le protecteur d'éblouissement s'est avéré le facteur limitant, suivi du DDI. Cependant, puisque le protecteur d'éblouissement est mince et peu solide, il ne semble pas apte à blesser les genoux durant l'éjection. Néanmoins, avec le harnais actuel (HCS), les pilotes ayant une longueur fessier-genou jusqu'à la limite actuelle de sélection des pilotes des forces canadiennes, c'est-à-dire 673 millimètres (99ieme centile), éviteront le protecteur d'éblouissement. Cette limite peut être augmentée quelque peu (~12 millimètres) si le protecteur d'éblouissement est considéré comme étant sans danger.

Tel qu'évalué, le harnais de torse ainsi que son siège modifié, sont plus limitant que le HCS actuel par près de 20 millimètres. Des coussins plus minces ainsi qu'une garniture arrière du harnais ramèneraient probablement la limite de longueur fessier-genou du harnais de torse en ligne avec celle du HCS.

Meunier, P. 2001. Ejection clearance in the CF188 aircraft. DCIEM TM 2001-136. Defence and Civil Institute of Environmental Medicine.

Table of contents

List of figures

List of tables

Introduction

Mass has traditionally been used as the sole anthropometric determinant for CF188 aircrew (Lefebvre, 2000). Currently, the CF188 Escape System safe ejection limits are such that they accommodate an all-inclusive throw mass of 183 kg (403 lbs) to 220 kg (484 lbs). This translates to a nude body mass range of 62 kg (136 lbs) to 98/102 kg (215/225 lbs), depending on the clothing and survival kit configuration. These limits exclude an estimated 6-8% of male aircrew[1] and approximately 20% of females[2].

The CF-18 Escape Systems Modernization Project was initiated to expand the range of allowable nude body mass to include individuals between 53 kg (116 lbs) to 111 kg (245 lbs). This would virtually eliminate mass restrictions for both males and females. However, since the anthropometric accommodation envelope of the cockpit has not yet been established in the CF188, it is not known whether all of the smaller and larger ejection seat occupants would be able to safely operate it. As a result, DCIEM was tasked by DTA (Director of Technical Airworthiness) to perform an anthropometric cockpit accommodation assessment.

Many key decisions remain to be made in the CF-18 Escape Systems Modernization Project that would affect the outcome of an anthropometric accommodation assessment. It was therefore not appropriate to conduct a full cockpit accommodation study at this time. However, since ejection clearance limits were of immediate interest, a partial assessment was required, to be followed by a full assessment once the escape system configuration was finalized.

The primary purpose of this study was to determine the upper limit of buttock-knee length that can safely eject in the current seat configuration using the Simplified Combined Harness (SCH), and in a slightly modified seat using the US Air Force Torso Harness (TH). A secondary purpose was to collect data that would enable three-dimensional modelling of the CF188 cockpit environment using computer generated human analogues. This document reports the findings of this study, which was carried out on July 10 and 11, 2001 in AETE Cold Lake.

[1] Based on data from Stewart, L. E. (1985). *1985 Anthropometric survey of Canadian forces aircrew.* DCIEM-TR-85-12-01, Defence and Civil Institute of Environmental Medicine, Toronto, Ontario
[2] Based on data from 1997 anthropometric survey of the CF land forces (Chamberland, A., R. Carrier, F. Forest and G. Hachez (1998). *Anthropometric survey of the Land Forces (LF97).* 98-CR-15, Defence and Civil Institute of Environmental Medicine, Toronto, Ontario) and the application of aircrew anthropometric selection criteria to the database of female data.

Method

Subjects

Since clearance problems affect mainly large subjects, nine of the largest subjects available from 4 Wing were recruited for this study. The subjects were selected from a list of CF18 pilots on the basis of their buttock-knee length (thigh length) measurement, which was the critical variable for this assessment. The subjects ranged from 63rd percentile to 99.9 percentile, as shown in *Table 1*. A number of additional measurements were made in order to satisfy the secondary goal of this effort, which was to be able to model cockpit accommodation using computer generated human analogues. These measurements are listed in Appendix A.

Table 1 Anthropometric selection variable

	Subjects								
Variable	***S1***	***S2***	***S3***	***S4***	***S5***	***S6***	***S7***	***S8***	***S9***
Buttock-knee length (mm)	694	642	619	633	680	637	627	664	641
Percentile (%)	99.9	87.7	63.4	80.0	99.4	83.7	73.5	97.4	87.0

Test conditions

The aircraft provided for the tests (tail number CF188-922) was missing the HUD, HSI and radio, normally located in the centre of the main instrument panel. Although this condition was not expected to influence the outcome of this study, it did make it slightly difficult for the subjects to adjust their seat to the usual position as well as preclude any type of clearance assessment of these structures to be made. As a result, the conclusions of this study should be viewed as temporary until the full accommodation study is performed.

The tests were carried out both in summer and winter flying clothing, using the current Simplified Combined Harness (SCH) (model MBEU 75183) and the US Air Force Torso Harness (TH) (model 68J369 (PCU-15)). The seat used with the Torso Harness was an ATESS[3]-modified SJU9/A. The modifications included the relocation of the emergency oxygen bottle to the backrest, a new back pad[4], a new seat cushion, and a seat-mounted regulator (DTA 3-6-9 file 11500-1).

An eye-safe laser[5] scanner was used to capture the posture of the pilots in the seat of the aircraft. The data were collected to serve as a template for the positioning of 3D mannequins inside a virtual CF18 cockpit, and as a means of validating the 3D human models. The results of this scanning and modelling exercise will be published separately.

The ejection clearance tests proceeded as follows:

[3] Aerospace and Telecommunications Engineering Support Squadron in CFB Trenton

[4] with lumbar support cushion removed

[5] Cyrax model 2500

1. After being measured, the subjects sat in the cockpit while wearing their summer flying suit without a harness or ALSE. The subjects adjusted their seat height as appropriate, and a 3D laser scan was taken.
2. The subjects then donned their harness ALSE and strapped-in;
3. A second laser scan of the subject was taken;
4. Shin clearance to the main instrument panel (MIP) was then measured with the subject's feet on the rudder pedals at the neutral position;
5. The seat was then raised to its highest position, and a second measurement of shin clearance was taken;
6. The seat was then pulled along the ejection rails by an overhead crane, making sure there were at least two pairs of slippers in the rails;
7. Knee clearance was measured relative to the DDI (Figure 1) and glareshield (Figure 2);
8. Steps 2 to 7 were repeated in winter clothing, with a third scan;
9. The test sequence was repeated with the other seat and harness combination.

Figure 1 *Clearance of DDIs.*

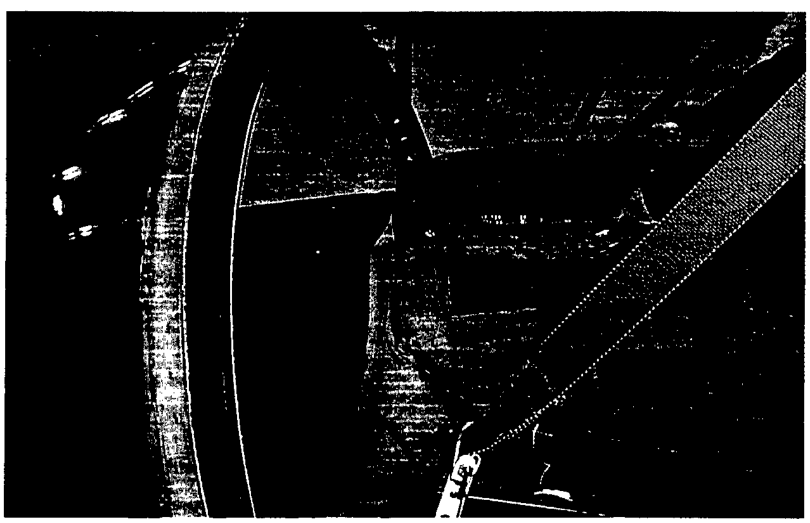

Figure 2 *Clearance of glareshield.*

Results and discussion

Shin clearance

The shin clearance results exhibited a relatively high degree of intra- and inter-subject variability that made them difficult to analyze. One of the reasons for this variability was the fact that foot position, that is, how the foot rests on the rudder pedals, was not controlled. It was found during the tests that different strategies were being used depending on the amount of shin clearance available. For instance, given enough clearance, the normal position would be to have the insteps rest on the rudder pedals. However, when shin clearance becomes an issue, large subjects choose to rest their heels on the floor of the cockpit thereby increasing the amount of shin clearance. While doing this could potentially impair a pilot's ability to actuate the brakes, it did not appear to be a problem for these large pilots, due to their long feet. However, this behaviour did cause discrepancies in the data and explains why a number of clearance measurements were smaller in summer clothing than they were in winter clothing.

Table 2 Shin clearance results.

			Shin clearance (mm)	
Subject	**Clothing**	**Harness**	**Seat at DEP**	**Seat full up**
1	Summer	SCH	12	10
4	Summer	SCH	20	20
6	Summer	SCH	21	25
7	Summer	SCH	5	10
8	Summer	SCH	10	18
9	Summer	SCH	54	38
1	Winter	SCH	0	0
4	Winter	SCH	22	20
6	Winter	SCH	10	10
7	Winter	SCH	15	13
8	Winter	SCH	0	0
9	Winter	SCH	52	32
1	Summer	Torso	10	0
2	Summer	Torso	33	18
3	Summer	Torso	21	23
4	Summer	Torso	23	25
5	Summer	Torso	30	20
6	Summer	Torso	10	15
7	Summer	Torso	0	5
1	Winter	Torso	12	0
2	Winter	Torso	29	15
3	Winter	Torso	18	20
4	Winter	Torso	0	12
5	Winter	Torso	40	17
6	Winter	Torso	15	20
7	Winter	Torso	0	0

While the majority of the results were in the 10 mm to 20 mm range, there was a surprising number of zero-clearance values (see Table 2). Furthermore, the majority of these were obtained with the torso harness.

Figure 3 gives an overall view of the results, which were expressed in terms of medians (dot inside the box), 25th to 75th percentile values (box), and the minimum and maximum values (whiskers). As expected, winter clothing tended to decrease the amount of shin clearance as evidenced by the decrease in medians, percentile ranges and extremes. As the seat went from design eye position to full up, the median shin clearance values tended to stay relatively constant, while the percentile ranges and maxima tended to decrease.

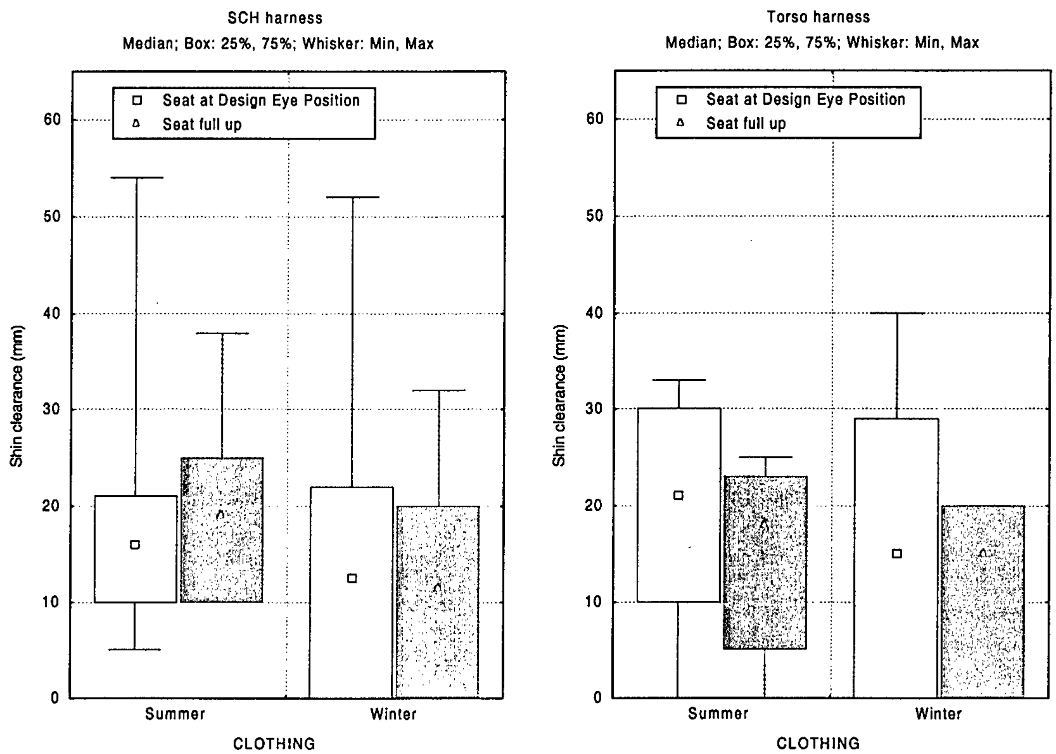

Figure 3 *Comparison of the effect of SCH and torso harnesses on shin clearance.*

Comparison of the SCH and torso harnesses showed little difference between the median values for summer and winter shin clearances. However, there appeared to be a difference in maximum and minimum shin clearances measured, with the torso harness values being lower. These results may be an indication that some of the pilots (i.e., those already in the seat full down position) are caused to sit higher and slightly forward in the torso harness compared to the SCH, leading to decreased shin clearance.

Pull-through

Since the front cockpit was found to be more limiting than the rear cockpit in terms of ejection clearance, pull-through tests were only conducted in the front. The clearance results are shown in Table 3.

Table 3 Ejection clearance results.

Subject	*Clothing*	*Harness*	*Knee clearance (mm)* DDI	*Glareshield*
1	Summer	SCH	31	28
4	Summer	SCH	88	80
6	Summer	SCH	93	75
7	Summer	SCH	90	74
8	Summer	SCH	89	65
9	Summer	SCH	113	94
1	Winter	SCH	42	34
4	Winter	SCH	85	65
6	Winter	SCH	88	76
7	Winter	SCH	83	62
8	Winter	SCH	53	40
9	Winter	SCH	95	74
1	Summer	Torso	40	30
2	Summer	Torso	70	49
3	Summer	Torso	103	89
4	Summer	Torso	85	75
5	Summer	Torso	92	73
6	Summer	Torso	70	61
7	Summer	Torso	58	44
1	Winter	Torso	34	23
2	Winter	Torso	73	44
3	Winter	Torso	80	71
4	Winter	Torso	71	60
5	Winter	Torso	84	64
6	Winter	Torso	83	64
7	Winter	Torso	74	53

The results of Table 3 were translated into equivalent maximum buttock-knee length values by adding knee clearance to individual buttock-knee lengths. Figure 4 summarizes the findings for both harness types in summer and winter clothing and equipment.

Several observations can be made from Figure 4. Firstly, there was a measurable effect of clothing, as evidenced by the sloping lines linking the mean equivalent maximum buttock-knee length values for summer and winter clothing. Secondly, the means obtained with the torso harness tended to be smaller than those obtained when wearing the SCH, although the difference was not statistically significant due to the variability in results. This variability can come from several sources, including intra- and inter-subject differences/preferences in sitting postures and measurement inaccuracy. Measurement inaccuracy was mainly due to the difficulty of measuring a small gap between the knees and aircraft structure, and the difficulty in finding the absolute minimum during pull-through, which implies stopping the crane at the appropriate time.

It is not clear why the torso harness measurements were so much more variable than the SCH results. Perhaps this was due to the novelty of the torso harness compared to the SCH, or the fact that there was only one size of harness available. One subject could not don the harness on top of his winter clothing. The impact of a small or improperly adjusted harness was that it required some of the subjects to slump in the seat in order to buckle the hip restraint strap, thereby causing variability in the sitting posture and therefore knee position.

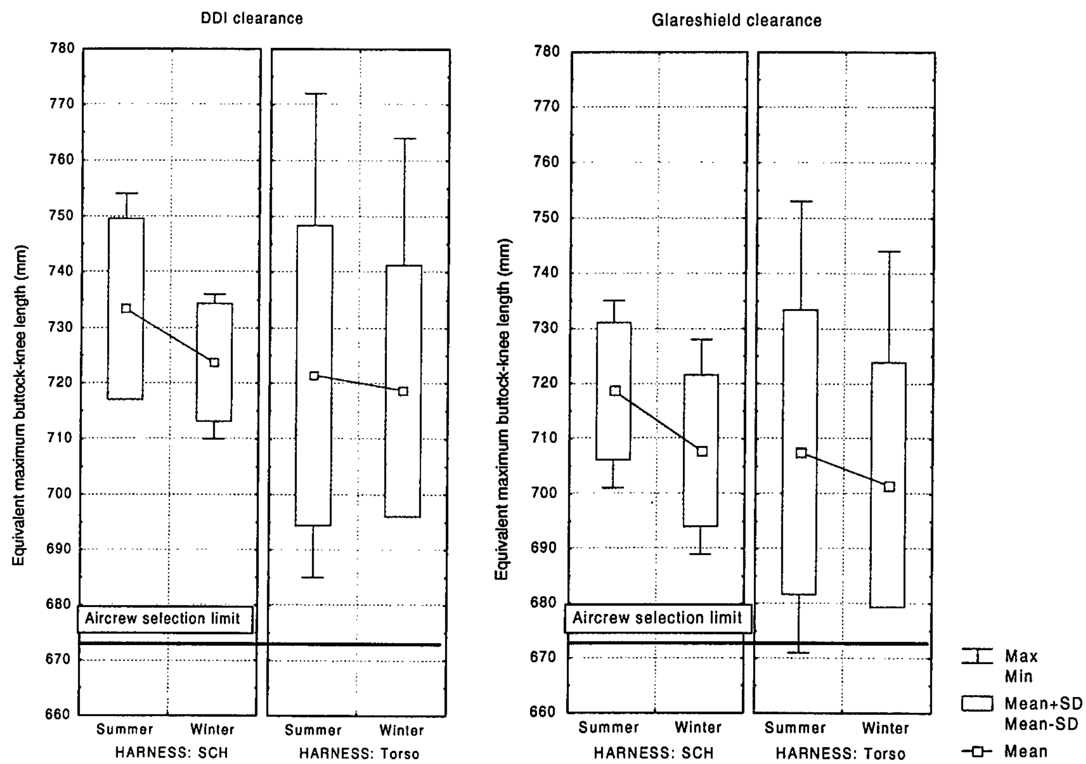

__Figure 4__ Assessment of maximum buttock-knee length for SCH and Torso harnesses in summer and winter clothing

Thirdly, the data show quite clearly that glareshield clearance is less than DDI clearance ($p<0.05$) by about 15 mm. In theory, ejection limits should be based on the glareshield since it is more likely to be hit upon ejection. However, the flimsiness of the glareshield suggests that it may have been designed this way in order to flex when struck and thus not cause injury. If this is the case then the DDI may be the only structure requiring attention, but this needs to be verified.

A relatively conservative approach was used to establish a maximum buttock-knee length, mainly because of the fact that a certain amount of knee movement is known to occur between the occupant and the seat during ejection. The exact amount of movement varies depending on the type of harness and its tightness at the time of ejection, among other factors. A study of ejection clearances performed by Cressman, 1973, concluded that a minimum clearance of 25.4 mm (one inch) was required between the knees and the aircraft structure to compensate for this "submarining" in the seat. This value was viewed as a strict minimum as he pointed out that there were cases of knee injuries in Canada and the US of "pilots whose thigh lengths were up to two inches less than the maximum safe limit for the aircraft". In the absence of data specific to the CF188, a strategy was used that consisted in using a conservative value for maximum buttock-knee length (the mean minus one standard deviation (the bottom of the boxes in Figure 4)) and

including Cressman's 25 mm buffer zone. This approach yielded the maximum buttock-knee length values shown in Table 4.

Table 4 Maximum buttock-knee lengths (including 25 mm safety gap).

		Max buttock-knee length (mm)	
Harness	***Clothing***	***DDI***	***Glareshield***
SCH	Summer	692	681
	Winter	685	669*
Torso	Summer	669*	657*
	Winter	671*	654*

* Values below the current CF aircrew selection limits of 673 mm

Table 4 indicates that most of the values obtained for the SCH harness exceed the current CF aircrew selection limits of 673 mm. However, if the glareshield is deemed to be non-hazardous, the upper limit could be increased somewhat. The torso harness and its seat cushions, in their current form, appear to cause a decrease in allowable buttock-knee length. As in the case of shin clearance, part of the reason for this is thought to be due to the thicker seat cushion, and the thick integrated back pad. Both of these differences contribute to the pilot sitting slightly higher and forward compared to the current situation. Although this arrangement may be suitable for the vast majority of pilots, it would not be suitable for large individuals. One way to compensate for this effect would be to provide thinner seat cushions and thinner back pads for those individuals.

It should be noted that pilots training on the CT-155 Hawk will, by virtue of that aircraft's small cockpit, have buttock-knee lengths well within the CF18's recommended maximum (Meunier, 2001).

Conclusions and recommendations

The glareshield was found to be the limiting factor in terms of allowable buttock-knee length, followed by the DDI. However, the glareshield is quite flimsy and is not likely to cause knee injury during ejection. Nevertheless, with the current harness (SCH), buttock-knee lengths up to the CF aircrew selection limit of 673 mm will clear the glareshield. This limit may be increased somewhat (~12 mm) if the glareshield is deemed to be non-hazardous. This conclusion must be viewed as preliminary since parts of the main instrument panel (HUD, HSI and radio) were missing from the tested aircraft. More definitive results will have to wait for the full cockpit assessment study.

Although the study was not designed to assess or model shin clearance, the preliminary indication is that shin clearance to the main instrument panel is rather limited. Some of the individuals tested had little or no clearance in winter clothing. More details will be available following the full cockpit accommodation assessment.

As evaluated, the torso harness seat cushions would reduce the maximum allowable buttock-knee length by nearly 20 mm compared to the current CF aircrew selection limits. Thinner seat cushions and back pads would mitigate or eliminate this problem, and bring the buttock-knee length limit in line with that of the SCH.

References

1. Chamberland, A., R. Carrier, F. Forest and G. Hachez (1998). *Anthropometric survey of the Land Forces (LF97).* 98-CR-15, Defence and Civil Institute of Environmental Medicine, Toronto, Ontario

2. Cressman, P. W. (1973). *Ejection clearances in Canadian Forces aircraft.* R-936, Defence and Civil Institute of Environmental Medicine, Toronto, Ontario

3. Lefebvre, V. (2000). *CF188 escape system physiological limits.* Project Tasking Directive 11680-12188-81 (DTA 3-6-3), Director Technical Airworthiness, Ottawa, Ontario

4. Meunier, P. (2001). *Cockpit accommodation assessment of the Hawk aircraft (CT 155).* DCIEM TR 2001-021, DCIEM, Toronto

Appendix A Detailed anthropometry

Table 5 Detailed anthropometric measurements of subjects (mm)

	Subjects								
Variable	***S1***	***S2***	***S3***	***S4***	***S5***	***S6***	***S7***	***S8***	***S9***
Abdominal depth	298	254	246	241	285	216	207	261	242
Acromial height	1566	1515	1480	1520	1631	1448	1472	1516	1470
Acromial height sitting	625	621	619	640	629	551	591	605	604
Acromion-radiale length	364	333	334	344	384	302	346	337	337
Biacromial breadth	409	433	394	389	412	367	438	411	425
Bideltoid breadth	543	495	471	496	540	444	496	498	531
Buttock height	1015	1922	954	942	1045	974	965	1143	927
Buttock-knee length	694	642	619	633	680	637	627	664	641
Cervicale ht	1628	1700	1525	1583	1652	1513	1566	1600	1539
Chest breadth	399	340	341	346	378	334	309	344	362
Chest depth	313	271	248	264	310	261	216	271	276
Hip breadth	419	388	338	367	368	326	351	363	383
Hip breadth sitting	445	425	354	372	401	321	362	368	390
Knee height sitting	603	579	577	575	634	569	583	578	561
Knee ht mid patella	534	516	512	510	574	515	506	517	491
Radiale-stylion length	302	288	284	274	295	277	294	271	277
Sitting height	936	990	924	943	942	882	925	947	936
Span	1898	1881	1872	1849	2004	1791	1970	1795	1833
Stature	1883	1876	1811	1832	1921	1779	1825	1852	1796
Thigh circumference	645	566	556	565	614	524	539	534	575
Thigh clearance	189	147	155	144	179	138	144	163	174
Waist circumference	1120	961	871	918	1006	822	800	954	918
Mass (lbs)	226	200	172	185	235	160	150	193	200

This page intentionally left blank.

DOCUMENT CONTROL DATA SHEET

1a. PERFORMING AGENCY DCIEM	2. SECURITY CLASSIFICATION UNCLASSIFIED Unlimited distribution-
1b. PUBLISHING AGENCY DCIEM	

3. TITLE

(U) Ejection clearance in the CF188 aircraft

4. AUTHORS

Pierre Meunier

5. DATE OF PUBLICATION August 1 , 2001	6. NO. OF PAGES 10

7. DESCRIPTIVE NOTES

8. SPONSORING/MONITORING/CONTRACTING/TASKING AGENCY
Sponsoring Agency:
Monitoring Agency:
Contracting Agency :
Tasking Agency: Director Technical Airworthiness

9. ORIGINATORS DOCUMENT NO. Technical Memorandum DCIEM-TM 2001-136	10. CONTRACT GRANT AND/OR PROJECT NO. 6ke12	11. OTHER DOCUMENT NOS.

12. DOCUMENT RELEASABILITY

Unlimited distribution

13. DOCUMENT ANNOUNCEMENT

Unlimited announcement

14. ABSTRACT

(U) An ejection clearance trial was performed on the CF188 to determine the longest buttock-knee length that can eject without hitting the aircraft structure. Nine large subjects (pilots) ranging from 63rd to 99.9 percentile buttock-knee length were recruited for the study. The tests were carried out both in summer and winter flying clothing using the current Simplified Combined Harness (SCH) and the US Air Force Torso Harness (TH), which required a modified seat.

Although the study was not designed to assess shin clearance, the preliminary indication is that shin clearance to the main instrument panel is rather limited. Some of the individuals tested had little or no clearance in winter clothing.

The glareshield was found to be the limiting factor upon ejection, followed by the DDI. However, since the glareshield is quite flimsy it does not appear likely to cause knee injury during ejection. Nevertheless with the current harness (SCH), buttock-knee lengths up to the CF aircrew selection limit of 673 mm (99th percentile) will clear the glareshield. This limit may be increased somewhat (~12 mm) if the glareshield is deemed to be non-hazardous.

As evaluated, the torso harness and modified seat are more limiting than the current SCH by nearly 20 mm. However, thinner seat cushions and back pad would probably bring the buttockknee length limit of the torso harness in line with that of the SCH.

15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) anthropometry, cockpit accommodation, CF188, Simplified Combined Harness, Torso Harness

Defence R&D Canada

is the national authority for providing
Science and Technology (S&T) leadership
in the advancement and maintenance
of Canada's defence capabilities.

R et D pour la défense Canada

est responsable, au niveau national, pour
les sciences et la technologie (S et T)
au service de l'avancement et du maintien des
capacités de défense du Canada.

DEFENCE & DÉFENSE

www.drdc-rddc.dnd.ca